EDITORIAL ARTICLES.

ON THE PRESENT STATE OF KNOWLEDGE IN BACTERIAL SCIENCE IN ITS SURGICAL RELATIONS.

As in every science, all new discoveries and great advances in recent medical science have been associated with the invention and exercise of new methods of investigation. But a short time ago we had occasion to remark in these pages that the original and era-making discoveries of Cohnheim in pathology were the outcome of new methods of research employed by him; and it is only necessary to glance at any physiological or pathological text-book in order to realize the multiplicity of such instances. The credit of having devised new and successful methods of research even supersedes that of having happily applied them; for they are means by which numerous scientific investigators are enabled to do new work, which would be entirely beyond the power and capacity of a single man.

In the history of the evolution of bacterial science no such important era is to be recorded as that which commenced only about four years ago. This epoch in bacteriology is marked by the introduction of a new method of cultivating bacteria, namely, that of employing hard and transparent soils for this purpose. This was done by Rob. Koch, of Berlin, and it is to this event that the present ascendency of the science of bacteriology is chiefly due. Koch's method is in fact to bacteriology what the cellular system has been to pathology, and the wave-theory to physical science.

It is true, new methods for the cultivation of bacteria have frequently been introduced since Pasteur, in 1857,[1] first inoculated his fluid media with germs: Klebs, in 1873, published his method of fractional culture.[2] Schroeter used solid media, as potatoes, for the cultivation of bacteria, in 1872,[1] and Klebs, 1873, used isinglass, and Brefeld[2], 1874, gelatine to prevent the evaporation and motion in the media.

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[1] Mémoire sur la fermentation appelée lactique. Compt. rend. Vol. 45.

[2] Beiträge zur Kenntniss der Micrococcen. Archiv für experimentelle Pathologie. Vol. I.

Hueppe, in his recent work on bacteriological technique[3] points out how, before Koch published his method of transparent solid culture-soils[4] all the elements of his system, had in reality already been discovered and made use of, and how it only needed a combining talent to produce a brilliant result.

But in spite of the fact that the elements of his method were known, the means of culture before Koch were highly inadequate and uncertain. Not only could, in former times, pure cultures not readily be obtained outside of the animal body with which to inoculate the soils, but when, by tedious processes, one organism had finally been isolated from a number, it was not always the one desired, but generally quite a different one. Even the employment of the one method which afforded comparatively the most satisfactory results, that of diluting the fluids containing the germs to such an extent that two drops of it only contained one germ[5] was encumbered by the conceded necessity of making 50 to 100 separate cultivations in each case[6] in order to secure reliable results—; and this proved a serious obstacle to its general adoption. The other methods, although very subtle in their conceptions, were only applicable after a pure cultivation had been procured.

One of the chief points, therefore, in Koch's system, was his use of his solid soils to obtain inoculable matter in a pure form,

The combination of the transparent with the solid properties of the cultivation-soils, which represents, as mentioned above, the chief features of Koch's method, was, however, no mere chance invention of his. It was, on the contrary, a full conviction and a perfect consciousness, that his method was at once the most simple and the most efficient mode of procuring pure cultures outside of the animal body, that imbued Koch when he first published his results; and it is impossible to read his communications, published in the reports of the Imperial Board of Health, without having this conviction impressed upon one. It is here that he insists on the immense importance of the *purity* of the cultures; that is to say, it is absolutely necessary that only one single kind of micro-organism should be present at one time in a growth used for scientific experimentation; or, in other words, a growth, to be a pure culture and fit for use in experiments, should only have proceeded from one single germ-element.

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[1] Ueber einige durch Bakterien gebildete Pigmente. *Cohn's* Beiträge zur Biologie der Pflanzen. Vol. I. Hft. 2.

[2] Methoden zur Untersuchung der Pilze. Verhandl. der phys. med. Ges. in Würzburg N. F. Vol. 8.

[3] Methoden der Backterien-Forschung, Wiesbaden, 1885.

[4] Zur Untersuchung von pathogenen Organismen. Mittheilungen aus dem Kaiserlichen Gesundheitsamt. Vol. I.

[5] *Naegeli*, 1871. *Naegeli* and *Schwendeuer*: "Das Microscop." 1877.

[6] *Fitz*; Berichte der deutschen chemischen Gesellschaft. Vol. XV. VII.

And here he also sums up the essential points requisite to all bacteriological investigations: that all the vessels used for cultivations be thoroughly disinfected and pure; that the covering of the vessels effectually exclude the entrance of germs suspended in the air; that suitable and properly sterilized media be employed; that none but the specific germs to be examined be contained in the material used for inoculation; and that no germ be introduced from the surroundings by means of instruments or from the atmosphere during the process of inoculation.

Although the strict enforcement of these rules is very difficult when dealing with fluid culture-soils, he points out that when solid soils are used, the inoculation is much simplified; as even if a germ from the atmosphere should fall upon the exposed surface of the soil during the process of inoculation, it would, in all probability, fall upon some other point than that chosen for inoculation and could here develop by itself without contaminating the intended culture, being confined to its place by the solidity of the soil. The chances of germs from the atmosphere happening to fall exactly on the point of purposed inoculation are still more diminished, when two or more vessels are used for each experiment. Thus Koch's method appears not only the most simple and easily effected method, but the most reliable and the most trustworthy at the same time.

Before these improvements and developments in the cultivation of bacteria were achieved, Koch had already added important features to the methods of examination of micro-organisms by his publications of

1878[1] and others,[2] in this case, as well, combining certain methods which till then had only been separately practiced, rather than originating completely novel ones.

Weigert[3] had used aniline dyes to color micro-organisms in microscopic specimens in 1875; Abbé had mathematically constructed his celebrated lens of illumination,[4] and Zeiss, of Jena, manufactured it in 1873. Immersion-objectives had been in use since Amici's time, and had been improved by Stephenson (1878); while the practice of drying liquid objects onto cover-glasses for the purposes of microscopical examination and the use of photography for procuring exact representation of microscopic objects appear to be of less recent date; but the methodical combination of all these devices into one complete system was first effected by Koch. The micro-organisms themselves have been the object of observation and study for ages.

Allusions to them are made by the Roman authors,[5] and it is probable that Leeuwenhoek (1680) saw them with his instruments.[6]

Ehrenberg was the first (1828) to observe them with scientific accuracy; and Schwann in 1837 asserted that the atmosphere was always laden with fermentive and putrefactive germs.[7]

Flügge[7] points out how the further development of bacteriological problems proceeded simultaneously in two different lines; the one relating only to such fermentive and putrefactive processes, which ultimately led to the acceptance of a vitalistic theory of fermentation, a question which, however, is not at present even fully solved; this problem we at present leave aside as more foreign to our subject. The other line of development was confined solely to the action of germs in disease; and this science ran its course quite independently of the others.

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[1] Untersuchungen über die Ætiologie der Wundinfections Krankheiten. Leipzig. 1878.

[2] Methoden der Bakterienforschung. *F. Cohn's* Beiträge zur Biologie der Pflanzen. Vol. I. Hft. 3.

[3] Bericht über d. Sitzung der Schles. Ges. für Vaterländ. Cultur. Dec. 10, 1875.

[4] *M. Schulze's* Archiv für microscop. Anatomie. Vol. 9.

[5] *Lucretius.* 95. B. C. *Terentius Varo,* 116-27 B. C. Quoted Amer. Journ. Med. Science, Jan. '85. Review. Sternberg.

[6] *Hoole's* translation, London, 1807, Vol. I., p. 207.

[7] vid. *C. Flügge.* Handbuch der Hygiene, etc., Von Pettenkofer u. Ziemssen. Vol. I. Abth. 2 Hft. 1.

Hufeland first pronounced diseases due to a "contagium animatum," and such men as Kirchner, Linné, Wichmann attributed the contagiousness of infectious diseases to the establishment of living germs in the body.

Henle,[1] indeed, at a time when nothing was definitely known by experiment, and when our present methods were not invented nor developed, theoretically defined and described the nature and properties of these agents of disease, anticipating later knowledge so exactly that his work played an important part in developing it.

After Bassi (1835) had traced the muscardine, a disease of the silkworm, and Tulasne, De Bary and Kühn certain diseases of grain and of the potato to micro-organisms, Pollender, 1855, and Davaine, 1863, were enabled to prove organisms the cause of splenic fever.

Enthusiastic experimenters (Hallier) even went so far in this line of thought that they soon claimed to have found the specific organisms of nearly all infectious disease.

Then, however, came a reaction, for De Bary proved Hallier's theories untenable and his experiments faulty. This was not without grave influence upon the further evolution of bacterial science, and, indeed, for a time the development of the knowledge of the cause of disease was seriously impeded.

Nevertheless, a period of renaissance soon appeared. Rindfleisch, Waldeyer and von Recklinghausen (1866, 1870) were able to demonstrate the presence of germs in pyæmic processes, and Hüter, Oertel, Orth, etc. (1868-1874), first threw light on the parasitic nature of such diseases as erysipelas, phlegmoné, diphtheria and puerperal fever. Pathological experiments were also conducted at this time by Coze and Feltz, Davaine, Hüter, Eberth, Klebs and many others (1866-1872), and Lister's antiseptic dressings were of utmost influence in developing the theories of infections of wounds.

Thus, little by little, and in spite of much opposition (Billroth, 1876), the germ theories gained ground and bacterial science so far developed that during the preceding year laboratories and professorial chairs exclusively devoted to the study of micro-organisms have been established in connection with many clinics or hygienic institutions, on the continent, in England, and of late also in America.[1] And although at the present time many adverse expressions of personal opinion may be heard from purely contemplative critics, the actual evidence in favor of the germ theory of disease is steadily increasing, and all those who have themselves done practical work in the special lines are firm followers of the new science.

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[1] Pathologische Untersuchungen, 1840, Handbuch der rationellen Pathologie, 1853.

We propose in this paper to review the more recent advances made of late in bacteriology, as far as they are of interest to surgery, in a concise form, though claim cannot be laid to exhaustiveness, and the matter will be restricted as much as possible to the more important publications of the last two years. To this further reviews will be added from time to time, as articles may appear.

Before turning to this subject, however, it is necessary to premise a few remarks on the nature of bacteria and the methods of cultivation now in use.

It suffices for the purposes of this paper to mention only a very few of the main biological and physiological conditions of the micro-organisms. Leaving aside all morphological systems of classification of these organisms, we simply bear in mind that they belong to the lower orders of plants (Cohn). We must, however, distinguish between the *fungi*, the *cryptococci* and the *schizomycetes*, with all of which the culture-experiments have to deal. All these forms consist, in their simplest state, of single cells, but they differ in their growth. The FUNGI grow by developing into long filaments, *hyphæ*, which frequently ramify, and the entire growth before fructification is called *thallus*. In contradistinction to this state the mass of ramified hyphæ is called *mycelium;* other hyphæ growing out of this mycelium develop sporangia, which contain *spores*, or they simply form spores. These latter are round cells, some of which are capable of motion; these, after a shorter or longer period, again grow and develop into hyphæ and form a mycelium. Common mould will serve as an example of this species. The fungi grow best on a slightly acid soil.

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[1] To the knowledge of the writer bacteriological laboratories have been instituted in the city of New York in connection with the Bellevue Hospital Med. College, in the Carnegie laboratory and the New York Polyclinic.

The CRYPTOCOCCI, instanced by yeast, grow by sprouting; that is to say, part of the membrane of the cell bulges out and is subsequently choked off. These micro-organisms cause fermentation in the media in which they are cultivated.

The SCHIZOMYCETES are either round in form (*micrococci*) or oval (*bacteria*, strictly speaking) or rod-shaped (*bacilli*) or shaped like threads, either straight or spiral (*spirillum, vibrio, spirochaete*) and often possess a rapid motion, produced by cilia. The micrococci are sometimes grouped in pairs, and are then called *diplococci*; when found in chains (*torula*) they are termed *streptococci*; when in bunches, *staphylococci*; when in large masses they are designated *zooglœa*.

The schizomycetes, also, chemically affect the media of cultivation; some of them produce colored pigments and many of them, when inoculated into the animal body, produce diseases. They demand an alkaline or neutral soil.

Their growth ensues either by division or by means of *spores*. The latter are small, round or oval, resistant bodies of great refractive power to light, which are found within the substance of the bacilli or filaments and which continue to live after the bacilli have become disintegrated, and which, in turn, under favorable circumstances, develop into bacilli, or into whichever form originally produced them—the germs and species remaining distinct in these as in other forms of vegetable and animal life.

Each of these three varieties mentioned may complete their evolution as soon as they meet with the conditions favorable to life,for instance, on culture soils, imitated from the media where the organisms were first observed.

The human body serves as a culture soil to certain forms of all the three varieties. The *actinomyces*, a species of fungus, gives rise to the disease called actinomycosis in man; species of cryptococci produce certain affections of the pharynx in man—the *mycoderma vini*, according to Grawitz, or according to a more recent author,[1] a microbe allied to *Bonnardeus monilia candida*: and *spirochaete Obermeieri*, one of the schizomycetes, is believed to be the cause of relapsing fever.

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[1] *Plant*, Beitrag zur systematischen Stellung des Soorpilzes in der Botanik. Leipzig. 1885. H. Voigt.

All such bacteria as are able to develop life in the human subject are termed *parasitic*. Bacteria cultivated outside of the human body are called *saprophytes*.

To determine whether bacteria can live without oxygen (*anaërobia*) or not (*aërobia*), what gases, etc, they produce, at what temperature they best thrive, and numerous other questions of this kind, complicated apparatus and very delicate chemical methods are employed in the laboratories.

Diverse theories have been put forward to explain the action of bacteria on the culture soils and on the human body. This action is generally a chemical one, and consists in dividing the complex organic compounds (as albumen) into their chemically simpler constituent parts (as peptone—leucin, tyrosin, etc.) Such chemical divisions are recognized as belonging to certain principles contained in organic secretions (as for instance, to pepsin in the gastric juice). Such principles are called *enzymē*, while similar chemical principles imagined to be the product of bacteria and to possess the power of rendering the human body diseased are called *ptomaīnes*. These theories are all more or less hypothetical; but in whatever manner the rationale of the action of germs on the body may be explained, that does not materially alter the relation of cause and effect between the presence of germs and disease.

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(TO BE CONTINUED.)